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ABSTRACT

In an investigation of the development of mapping as distinct from drawing, 39 middle and lower class Cambridge, Massachusetts children in kindergarten and first- and second-grades were shown a small three-dimensional model town, asked to make a smaller, three-dimensional copy of the model, and then asked to make a map showing each item in the town and where it was located. Changes seen in the children's approach to the mapping problem can be described in terms of the following five trends: (1) an increased tendency to render all items on the model terrain, and those only; (2) a decrease in the amount of detail used in rendering items; (3) an increase in accuracy of spatial arrangement and orientation of map symbols; (4) an increased concern for proportion; and (5) a shift in drawing angle from canonical, or frontal perspective, to a birds-eye view. In general, findings suggest that it is important to teach children the differences between various forms of graphic representation, rather than ignoring them or leaving them implicit. Not to do so, it would seem, amounts to a subtle kind of educational inequality which may have a major impact on the development of literacy, as understood in its most encompassing and fundamental sense. (RH)

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Mapping Symbolic Development

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Paper presented at the Sixteenth Annual Symposium of the Jean Piaget Society, Philadelpia, May 31, 1986.

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Mapping Symbolic Development

If we were to describe literacy strictly in terms of fluency with written language, we would miss a fundamental aspect of human communication. That is, our fluency in reading and creating a broad repetoire of records. To make sense of a newspaper, a reader needs to know how to decode more than words, she needs to know how to make sense of a number of different kinds of text: a table of contents, a help-wanted page, a comic strip. Equally, she must be able to understand quite a range of graphic symbols: a photograph of a proposed building site, a political cartoon, the slope of the Dow-Jones. In other words, a fundamental characteristic of human symbol use is the capacity to tune our forms of representation -- whether words or graphic forms -- to particular purposes.

Consider the several different renditions of houses and hiding places made by a 7-year-old and reproduced in Figure 1 below. Although her notations may not yet be fully conventional, this child already understands the constraints and rules of different symbol systems. She records the "same" information about hiding places differently depending on whether she is using words in text, distance within a bar graph, pictorial shapes in a drawing, or labeled and simplified shapes within a map.

Insert Figure 1 about here

It is this ability to adapt record-making to particular types of information and tasks that gives us both a varied repetoire of approaches to notation, and the ability to tune our

record-making continuously to newly emerging purposes and tasks.

The domain of graphic representation is a very rich area in which to study the issue of learning to adapt symbols to specific ends. As the newspaper example suggests, it is possible to turn the same basic raw materials --lines and shapes -- into either pictures, maps, diagrams, or charts. In each case the maker abides by a set of rules or practices about what is to be recorded and how it is to be shown. Someone making a sketch is likely to include the visual information about landmarks in their natural setting as seen from a particular point of view. In that drawing, the house at #23 Union Street might appear as a three-story, gray-shingled, Victorian structure with a Mansard roof and syringa bushes in the front yard. However, if the same person were making a map of the neighborhood, she would set down a different set of visual "facts", in a distinct format. In all probability, she would draw the area as seen from a birds-eye perspective and strip down her information to the location of major buildings, landmarks, and thoroughfares. The house would appear as a square, set back one half-inch from the double line labeled "Union".

By using just this contrast between drawings and maps, we have tried to delineate the process by which children come to discriminate among the varied graphic formats which they can use to record their knowledge of the visual-spatial world, specifically their ability to respond to the unique demands of formats such as graphs, diagrams, drawings, and maps.

This approach contrasts with more familiar ways of thinking

about the development of mapping skills. Typically, children's maps have been used as a means to investigate other aspects of cognition such as children's knowledge of a particular space (Hart, 1979; Siegal, 1981), their perspective-taking skills (Piaget and Inhelder, 1956); their memory (Verdonick,1986); or individual differences in patterns of development (Feldman, 1980). Only recently have researchers documented the development of map-reading and map-making skills per se (Liben and Downs, 1985). However, the question of how maps differ from other forms of graphic representation, has, until now, been an investigation reserved chiefly for philosophers and semioticians (Downs, 1985; Goodman,1968).

In order to look at the development of mapping as distinct from drawing, we presented 39 middle and lower class Cambridge, Massachusetts children in kindegarten, first, and second grades with the small 3-dimensional model terrain pictured in Figure 2. Given a set of props, each child was asked to make a smaller, but still three-dimensional, reconstruction of the model terrain. Only after completing this task were they given paper and pencil, and asked to make a map, showing "what each item in the town is, and where it is located".

Insert Figure 2 about here

By first grade, children understand the raw materials required for success at the mapping task. Perceiving the number, size, and location of items in the town is not a problem for them: all of the children were able to reconstruct the model on a smaller 3-dimensional scale with reasonable accuracy. Similarly, encoding per se poses no problem. Asked to make a tree, a

house, or a road, all these children are able to produce very readable and even sophisticated renditions of the objects. But what develops more slowly is children's ability to tune their record-making to the particular demands of map-making as compared to drawing.

The emergence of the ability to make a map, as compared to a drawing of the terrain, can be appreciated by sampling the ways in which individual children make maps a different points in time. When 5-year-old Justine makes a map (see Figure 3), she borrows from her already well-developed drawing skills and creates a landscape of the terrain. For instance, Justine chooses to render only the two buildings which face her as she looked at the model. She positions them both on a bed of grass at the bottom of the page, ignoring everything about their actual positions except that the school is to the right of house #17. She also moves aside the two trees in front of the house in order to provide a full view of its front face. By virtue of this, she fails to distinguish between the ways she encodes relationships such as beside, in front of, and between. Effectively, Justine draws a picture which includes a few of the items on the model. She places them in their most typical positions, and adds details which help to set the scene, such as sun and clouds, birds and weathervanes. Clearly, for Justine there is little distinction between a map and a drawing.

Insert Figure 3 about here

By comparison, Helen, (see Figure 4) is careful to represent every item in the town, not just those which faced her or which

she found interesting. Neither has she included items such as birds and weathervanes which are not present in the model. The most important leap towards mapping has occurred in her arrangement of these items. Although distances between items are still distorted, items are now incorporated into an overall plan, which reflects accurate topological relationships (hill in upper left, road lying between house and school, etc). While she has used partial occlusion to imply that the playground is behind the school, she does not carry this system over to the trees in front of the house. Instead, she chooses to move them aside, just as Justine had done the year before.

Insert Figure 4 about here

There are other drawing traditions which Helen has failed to adapt in the service of mapping. For instance, the prominence of the buildings in her rendering of the town is deceiving. The buildings seem to act as the subjects of a drawing and get preferential treatment. They loom over the other items in the town such as the hill and the playground, both of which are actually quite a bit larger. In addition, although she no longer places buildings along the bottom edge of the paper, there is evidence that she still sees the bottom of the page as the "ground" and the top as the "sky". She references and orients all items in terms of these lines, instead of angling them towards the roads. Her maintenance of the frontal view of buildings supports this notion, and only leads to more confusion over how this product is to be interpreted. Is the distance to the top of the page representing height (as in drawings) or depth (as in maps)?

It is not until the age of seven that children begin to realize the specific and distinct demands of mapping and drawing. Thus, Daryl (see Figure 5) knows that a map shows only width and depth. By adopting a birds-eye view, he excludes information about the volume of buildings entirely. However, in order to show the rise of the hillside, he adopts the system of contour lines often used by cartographers. In his effort to highlight the size and position of items on the terrain, Daryl has abandoned many of the details that make these items identifiable in a drawing: for example, the bushes around one house are shown as squares. To compensate, he has added labels to parts of his map in order to help the reader. As he pushes still further toward abstract, stream-lined representation, it is likely that he will find the need to use still more labels, or even a legend.

Insert Figure 5 about here

In summary, changes seen in children's approach to the mapping problem can be described in terms of the following six trends:

First, an increased tendency to render all items on the terrain, and only those on the terrain. In a drawing, a maker is free to select among landmarks and even to invent features. In a map, a maker must render all major landmarks and may not introduce new ones. We found that the percentage of children able to limit their maps to terrain items increased from 17% to 33.3% to 37% across the three years.

Second, a decreases in the amount of detail used in rendering items. Drawings typically include quite a rich

amount of detail, whereas map symbols are more tailored, concise, and clearly legible. We found that an increasing number of third graders used only one defining detail to distinguish between buildings on their maps. The percentage of children using this strategy increased from 5.8% to 9.8% to 13.7%. Along with the decrease in drawn details came the gradual increase in symbol labels, from 0.0% in kindergaten, to 1.9% in first grade, and 3.9% in second grade.

We found an increase in accuracy of spatial arrangement and orientation of map symbols. In a drawing, a maker can play with the spatial relations among objects and with their orientations, creating a scene which is most commonly anchored to the bottom of the page. In a map, the spatial arrangement of items and distances between them must not be distorted. Across the three years of our study, we found a dramatic increase in the tendancy to locate items all over the page, in accurate topological relationships. The proportion of children with this strategy increased from 9.8% to 45.0% to 68.6%.

In addition, there was an increased concern for proportion. In a drawing, the maker has the option of playing with the way in which she represents the relative size of items or areas, in order to highlight the most interesting parts, or through the use of perspective techniques. This is not the case in maps, where proportional representation of sizes is crucial. We found that children were increasingly able to accurately represent relative size in their maps, with the percentage of children moving from 11.7% to 23.5% to 37.2%.

Finally, there was a shift in drawing angle from canonical

to a birds-eye view. In a drawing, the point of view is typically from the front, or the most canonical vantage point. Maps, in the interest of preserving accuracy of spatial layout, most typically present a birds-eye view of both terrain and landmarks. We found a steady increase in the number of children employing a birds-eye view in their maps from 5.8% to 9.8% to 25.4% in second grade.

While changes on some of these dimensions might be explained by an overall increase in the accuracy of graphic representation, changes along others cannot not be explained in this way. These shifts indicate that the children are developing a distinct graphic system, in which information in presented not only accurately, but according to a set of rules peculiar to maps. The true test for this will be to trace the changes that occur when children in this age group are asked to make drawings, not maps, of the town. This study,also funded by the Carnegie Corporation, is presently underway at Project Zero.

We have seen that, across the three years of the study, all children move towrds creating increasingly map-like renditions of the terrain. However, at age five, individual children are already at quite different points in the process, and continue to develop their mapping skills at different rates. Justine and Daryl represent just such a contrast. As seen above, Justine's kindergarten map relies heavily on drawing strategies, and in the ensuing two years, she alters that approach only partially. In her first and second grade maps, Justine does adjust her spatial arrangement, and adopts a birds-eye view for items such as the

roads and bridge. She drops all fictional items, replacing them with laborious and faithful detail. Nevertheless, she does not begin to abstract her map symbols into iconic forms.

A longitudinal look at Daryl's maps suggests what may occur between ages 5 and 7 for the graphically sophisticated child. Even in kindergarten, Daryl is attempting a birds-eye view. In an ingenious solution to the perspective problem, he "squashed" each building in order to show both the roof and the four sides. By first grade, Daryl abandons even this mix of perspectives. He is able to create a map from a consistent birds-eye view, and adds labels. Once he has broken free of the obligation to draw items realistically, he moves into the high level abstractions (such as contour lines and square bushes) that characterized his second grade map.

Given this kind of variance among children, and the fact that these skills are essential to broad forms of symbolic development, it is important to teach children the differences between various forms of graphic represntation, rather than leaving them ignored or implicit. Yet, the classrooms we visited in this study varied tremendously in whether or not they afforded children the opportunity and motivation to think about these issues of symbol use. In some classes, teachers and children openly discussed the similarities and differences between pictures, maps, diagrams, and charts. Elsewhere, children recieved what we have come to think of as a much more local instruction, which focuses only on the matter at hand, and never involves the opportunity to stand back and reflect upon the ways in which the same symbol system can operate in different

contexts. The result, we believe, is a subtle kind of educational inequality, which has major impact on the development of broader and deeper forms of literacy.

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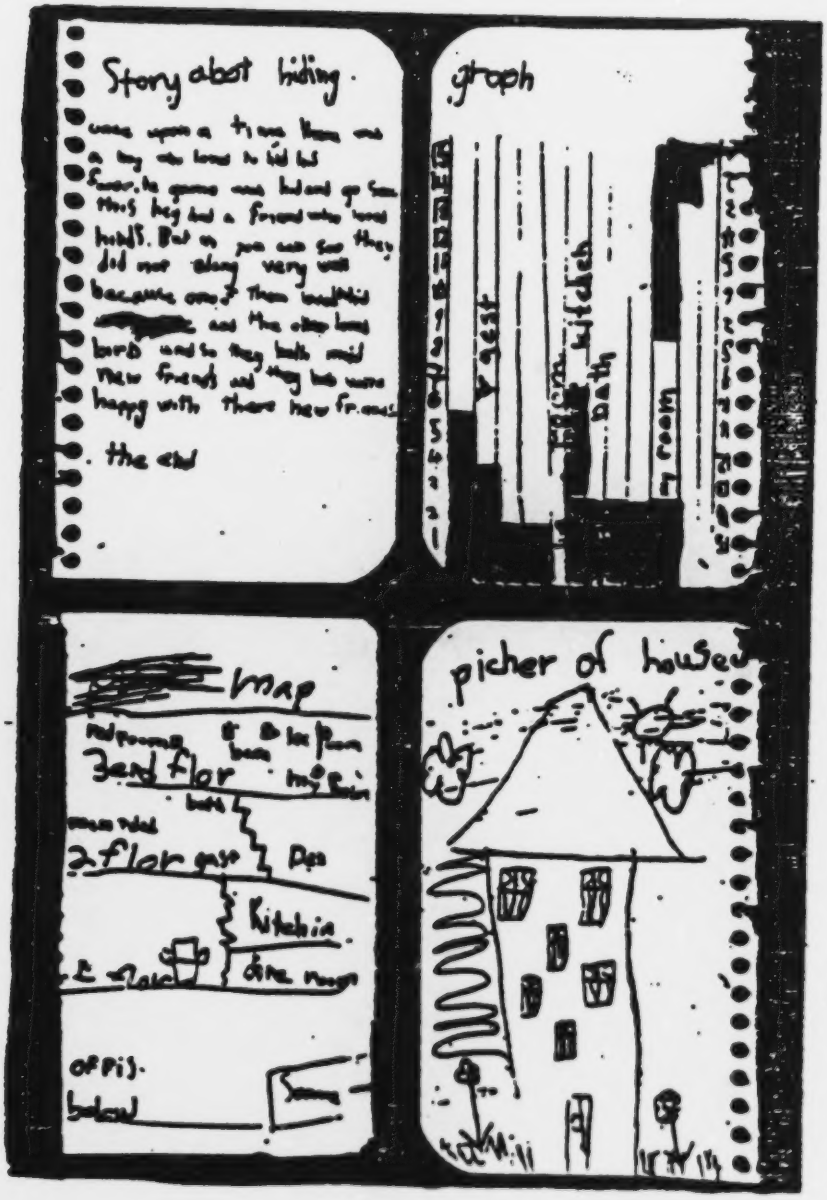

Figure 1: A 7-year-old's various notations of information about hiding places.

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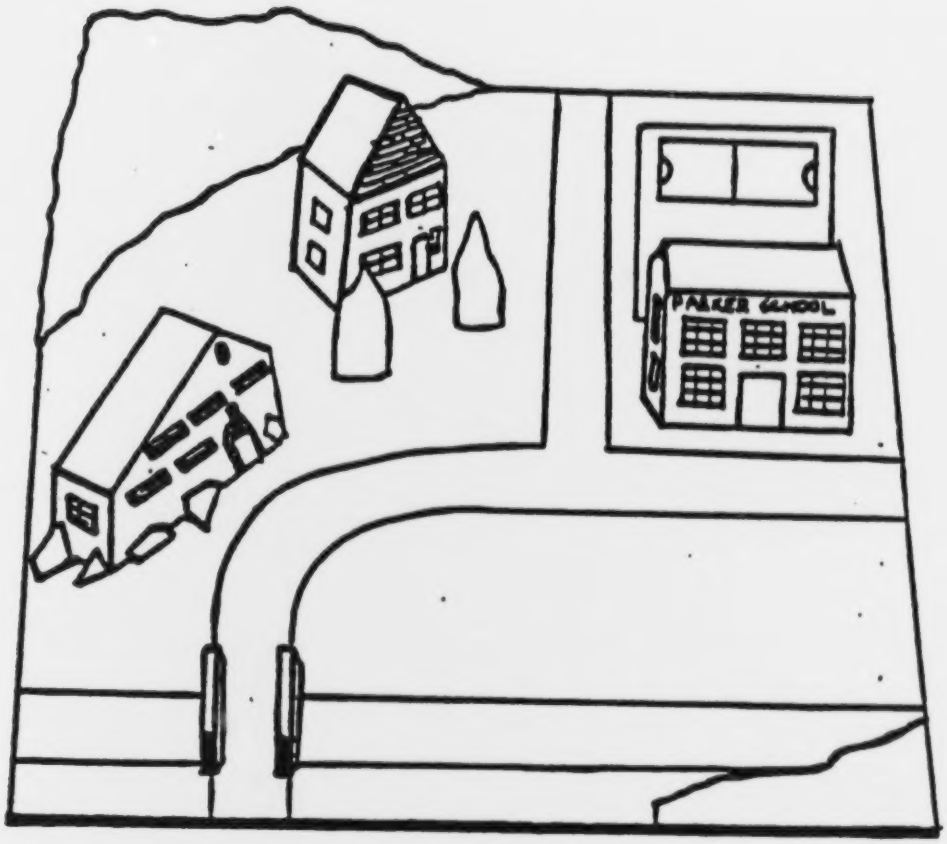

Figure 2: The model terrain children were asked to map.

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Figure 3: Justine's 5-year-old map.

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Figure 4: Helen's 6-year-old map.

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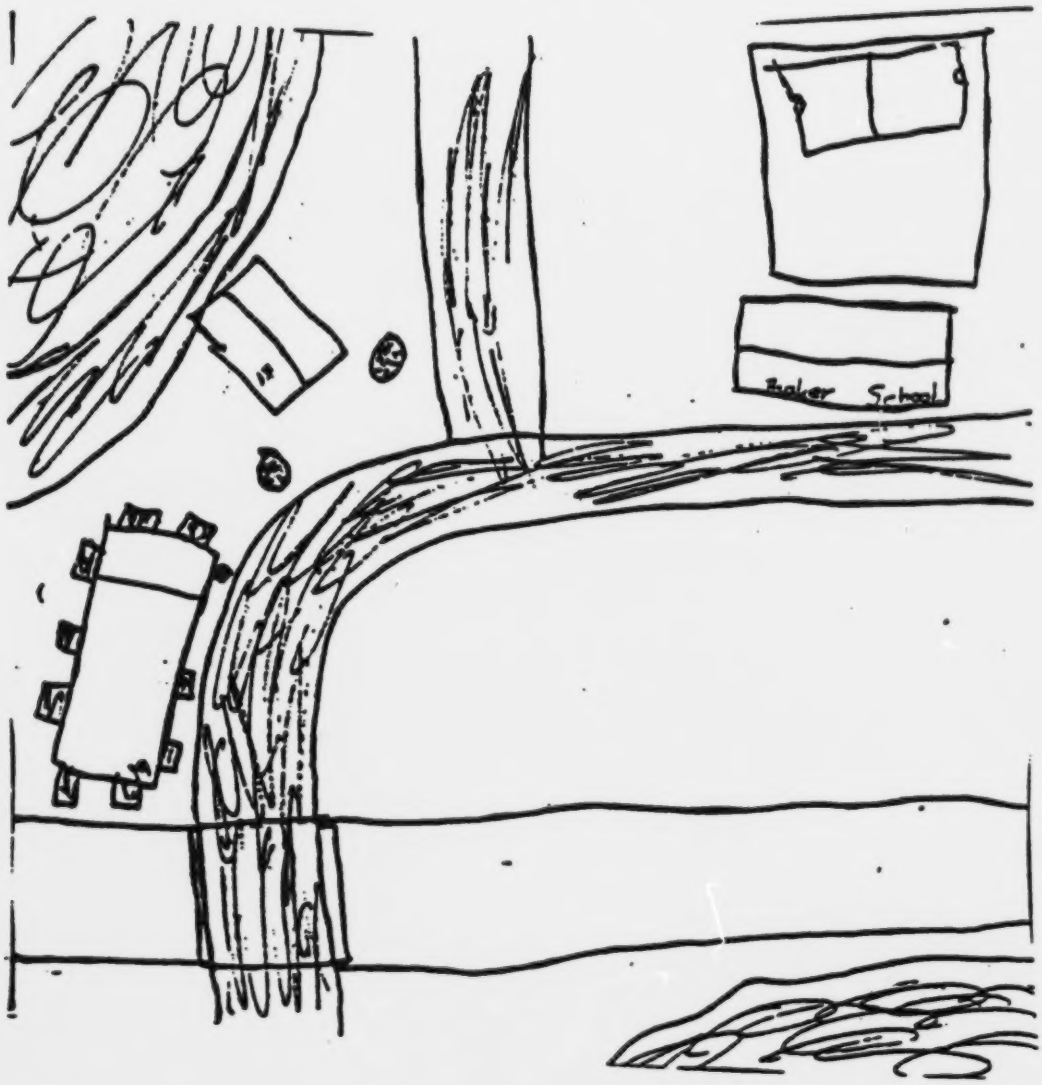

Figure 5: Daryl's 7-year-old map.

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